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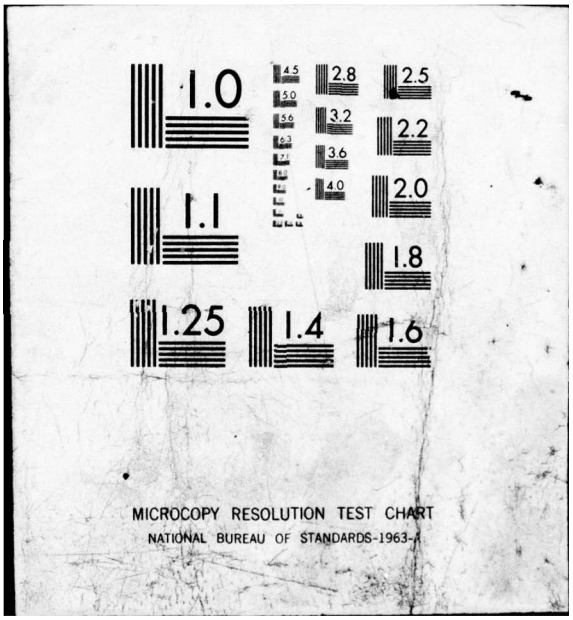
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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

Life Cycle Support of
Computer Software Aboard
Fast Attack Nuclear Submarines (SSNs)

Study Project Report
PMC 77-1

Charles E. Fox
GS-14 DNC

FORT BELVOIR, VIRGINIA 22060

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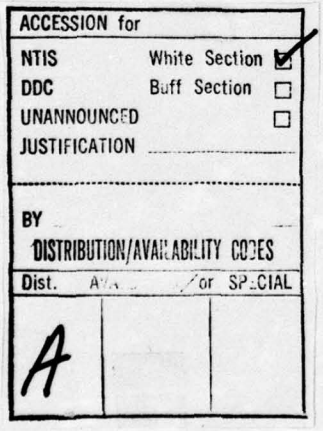

by

Charles E. Fox

GS-14 DNC

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Study Project Advisor
LCDR S. Anderson

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: Life Cycle Support of Computer Software Aboard Fast Attack Nuclear Submarines (SSNs).

STUDY PROJECT GOALS: Review DOD and Navy policy and procedures for computer software management and compare with the approach being implemented for the combat control system aboard Fast Attack Nuclear Submarines.

STUDY REPORT ABSTRACT: Current DOD and Navy policy and procedures are reviewed and compared with current procedures being implemented to manage computer software aboard Fast Attack Nuclear Submarines (SSNs). The specific area of comparison is the Life Cycle Support of the operational software for the combat control system aboard SSNs. Conclusions and recommendations of the review are provided for the program manager within the Naval Sea Systems Command.

Keywords

Life Cycle Management
Computer Software

NAME, RANK, SERVICE	CLASS	DATE
Charles E. Fox, GS-14, DNC	PMC 77-1	May 1977

EXECUTIVE SUMMARY

The purpose of this report is to review DOD and Navy Policy and procedures for computer software management; compare this DOD and Navy Policy with the approach now being implemented for the combat control system aboard Fast Attack Nuclear Submarines (SSNs).

DOD and Navy documentation governing operational software management is identified with the pertinent sections highlighted and presented as the basis for comparison with the approach being implemented for the combat control system. The details of the organization and the procedures governing the combat control systems operational software management are discussed.

The review concludes that the current procedures being implemented are conforming to DOD and Navy policy. In addition two recommendations are made to improve the combat control computer software life cycle management.

ACKNOWLEDGEMENTS

The assistance and sound guidance provided by LCDR Sue Anderson during the preparation of this report is most appreciated.

In addition I would like to thank my wife, Tricia, especially during her 37th week of pregnancy, for the tollerance and assistance she has provided during the development of this report as well as throughout the PMC 77-1 Course.

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SECTION I

INTRODUCTION

1. BACKGROUND

Introduction of computers into major weapon systems dates back more than three decades; these computers were of the hard-wired analog type. However, embedded digital computers have been used in weapon systems for more than a decade. The trend has been to eliminate hard-wired, limited purpose weapon systems and replace them with high speed, digital computer, multipurpose weapon systems. This approach was taken such that a weapon system would have increased flexability to meet an ever increasing military threat. With the increased flexability additional advantages are also envisioned, such as reduced time to counter a new threat, reduced manpower to both operate and maintain the equipment as well as reduced weapon systems cost.

In recent years there have been substantial increases in the time required to reprogram the digital computer driven weapon systems and increases in cost as well as increases in operator and maintenance personnel. These increases have helped drive the Defense Budget to a souring approximate $120 billion dollars for FY 1978. The contributions due to computer hardware and software are not clearly identifiable. However, predictions of future requirements indicate that software cost will be approximately eighty per cent of the total computer cost by 1985. The Deputy Assistant Secretary

of Defense for Material Acquisition, Jacques Gansler, was quoted in a 1976 Aviation Week (R9:41)[1] as saying "According to our estimate, the Pentagon is spending more than three billion annually for software for defense systems." Top DOD officials as well as Congress have initiated action to determine the reasons for the increases as well as initiated action to control the cost.

Within DOD several studies have been undertaken and new policies and procedures have been established. The most recent policy is DOD Directive 5000.29; Management of Computer Resources in Major Defense Systems, dated 26 April 1976 (D1). This directive establishes policy for the management and control of computer resources during the Life Cycle of major defense systems. The topics identified in the policy are outlined as follows:

A. General

B. Requirements Validation and Risk Analysis

C. Configuration Management of Computer Resources

D. Computer Resource Life Cycle Planning

E. Support Software Deliverables

F. Milestones Definition and Attainment Criteria

G. Software Language Standardization and Control

[1]This notation will be used throughout this report for sources of quotations and for major references. The first alpha numeric designator is the source listed in the bibliography. The second number, after the colon, is the page number in the reference.

2. STATEMENT OF PROBLEM

The U.S. Navy is currently deploying Fast Attack Nuclear Submarines (SSNs) that have high speed digital computers as the heart of the weapon system. The systems on a single ship have software programs that are approaching a million words of instructions. These weapon systems were designated to have a great deal of flexiability by being reprogrammable to meet new missions/threats. However, the systems were designed several years back, i.e. typical period of time from design to deployment is between seven and ten years. This means the systems were not:

A. Programmed in higher order language (HOL)

B. Were not placed under tight configuration control

C. Were not subjected to rigorous life cycle planning as required by DOD 5000.29 (D1)

Even though these systems were developed prior to the issuance of 5000.29 they have been recently subjected to similiar disciplines of management and control as required by the policy. In particular, Configuration Management and certain aspects of Life Cycle Management have been implemented. The major area of discrepancy is in the HOL and at this writing it appears the cost and time required to reprogram is not feasible. However, attempts are being made to program new modules with HOL and incorporate them into the operational programs.

3. SCOPE OF PROJECT

The author's current prime interest is in the overall management of computer resources aboard SSNs. However, this is a broad subject area and due to time constraints of this paper, the full topic is outside its scope. Therefore this paper will be limited to the area of Operational Software Life Cycle Management for the Combat Control Systems Aboard SSNs.

4. GOALS OF REPORT

The two goals of this project are as follows:

A. Review current DOD and Navy policy and procedures for Operational Life Cycle Management of Computer Resources and compare with the approach being implemented for the Combat Control Software aboard SSNs.

B. Identify improvements/changes to the current approach.

SECTION II

LITERATURE REVIEW

1. DOD POLICY

The prime DOD Directive is 5000.29 (D1) and the specific areas to be addressed in this report are contained within paragraph V section C and paragraph V section D. Paragraph V section C pertains to Configuration Management of Computer Resources and the directive states the following:

> Defense System Computer resources, including both computer hardware and computer software, will be specified and treated as configuration items. Baseline implementation guidance for this action is contained in DOD Instruction 5010.21.

Paragraph V section D, Computer Resource Life Cycle Planning, contains the following:

> A computer resource plan will be developed prior to DSARC II, and will be maintained throughout the life cycle. The purpose of the plan is to identify important Defense system computer resources acquisition and life cycle planning factors, both direct and indirect, and to establish specific guidelines to ensure that these factors are adequately considered in the acquisition planning process. Examples of factors to be addressed are the following, as applicable:
>
> 1. Responsibilities for integration of computer resources in to the total Defense system and the determination of overall system qualify.
> 2. Personnel requirements for developing and supporting computer resources.
> 3. Computer programs required to support the development, acquisition, and maintenance of computer equipment and other computer programs.
> 4. Provisions for the transfer of program management responsibility after initial system operating capability has been achieved; provisions for system/equipment turnover.

The DOD Instruction 5010.21 (D2) as identified in paragraph V section C above is a detailed instruction on Configuration Management and has been implemented in great detail at the DOD component levels. The detailed component level will be addressed under the next subsection "Navy Procedures". As can be seen from the previous paragraphs the 5000.29 (D1) directive is not specific in the operational life cycle support area and the main thrust of the directive is summarized by the following three statements:

1. It outlines areas for computer resource management.

2. It establishes a Management Steering Committee for embedded computer resources at the Assistant Secretary of Defense (ASD) level.

3. It places the development and implentation of procedures at the DOD component level.

2. NAVY PROCEDURES

With the development and implementation responsibility for the policy stated in DODD 5000.29 being placed on the DOD component, the next documentation to be reviewed is the Navy's. The documents that are related to this study reduce down to a small number. The first document is in the configuration management area and is NAVMATINST 4130.1A (D3). Configuration Management (CM) in this instruction is broken into the following topics:

- Configuration Identification
- Configuration Control
- Configuration Accounting
- Configuration Audits

In addition the instruction spells out the details for a Configuration Control Board (CCB) as well as details on Class I and Class II Engineering Change Proposals (ECPs). Further guidance has been issued from the Chief of Naval Material on Configuration Management per NAVMATINST 4130.2A (D4). This instruction sites the above CM instruction and identifies the following action:

> Action - All components of the Naval Material Command responsible for development, procurement, production and maintenance of computer software associated with tactical digital systems, or technical computer systems shall review their existing instructions and procedures and initiate necessary changes....

The remaining applicable documents are:

1. SECNAVINST 3560.1 (D5) which establishes the documentation necessary to control computer programs during their life cycle.

2. NAVMATINST 5230.5 (D6) which establishes the Tactical Digital Systems Office in the Chief of

Naval Material for review and control of digital systems.

3. ADDITIONAL AREAS OF INFORMATION

The Air Force has issued numerous regulations for computer resource management. The prime regulations, which closely parallel DOD 5000.29, is the AFR 800 series, specifically, AFR 800 - 14 Volume I dated 12 September 1975, "Management of Computer Resources in Systems", Volume II dated 26 September 1976, "Acquisition and support Procedures for Computer Resources in Systems."

SECTION III

SSN OPERATIONAL SOFTWARE SUPPORT

1. DOCUMENTATION

The SSN operational life cycle support is currently being performed in accordance with three basic documents which were generated by the Naval Underwater Systems Center (NUSC), Newport, RI and approved by the Naval Sea Systems Command (NAVSEA).

The first document is "The Plan for the Management of the Life Cycle Support Activity" dated 15 April 1976 (D12). It contains detailed information on the upper management structure, from the Chief of Naval Operations down to sub-system agencies, Life Cycle Support Organization, Operational/Test facilities and outlines of required funding.

The second document is "A Plan for the Management of Software Maintenance Facility" dated 23 November 1976 (D13). This document is an extension of the previous document with detailed block diagrams of hardware layout and facilities and outlines of required funding.

The third document deals with "Configuration Management Plan for Life Cycle Support of SSN Operational Computer Programs", dated 15 December 1976 (D14). This document also addresses the management organization, and addresses the specific cycles for review and approval of software. The main thrust of the document is the configuration management of the software. This has been patterned after the procedures

for hardware configuration management and follows NAVMATINST 4130.1A dated 1 July 1974, titled "Configuration Management." (D3).

2. ORGANIZATION

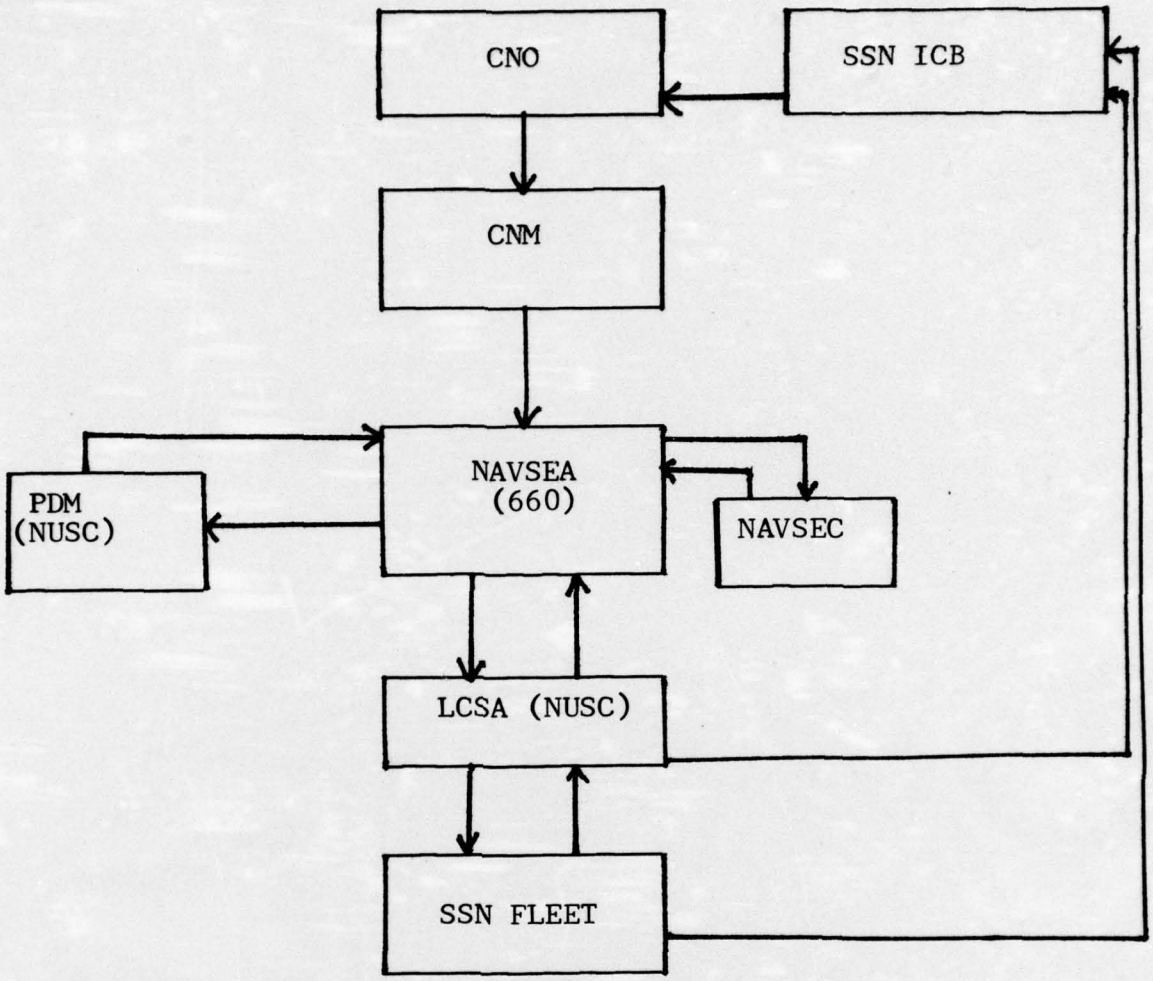
Figure 1 is a modification to the Organization Chart provided in (D13). The modification is made to focus attention on the areas of control placed on SSN operation software.

NAVAL SEA SYSTEMS COMMAND

The single point of contact responsible for the planning, programming and budgeting for the management of the operational combat control software for SSNs is the Naval Sea Systems Command (NAVSEA), Code 660D. This assignment was made via the Chief of Naval Material (CNM) (D15) at the request of the Chief of Naval Operations (CNO) (D16).

IMPROVEMENT CONTROL BOARD

The SSN Improvement Control Board (ICB) was established by CNO (D17) as a means of reviewing recommended improvements to operational software, assessing their cost and schedule impacts if implemented and finally establishing a priority of those approved. This board meets approximately every two to three months and consists of the following voting members: The Chief of Naval Operations, the Chief of Naval Material, the Naval Sea Systems Command, the Commander Submarine Force, U.S. Atlantic Fleet, and the Commander Submarine Force, U.S. Pacific Fleet, the Chief of Naval Operations serving as Chairman of the Board. In addition there are other attendees such as the Commander Operational Test and Evaluation Force, the Commander, Submarine Development Group, the Fleet Combat



ORGANIZATION FOR SSN OPERATIONAL
SOFTWARE SUPPORT

Figure 1

Direction Systems Support Activity, the Naval Underwater Systems Center, and the Naval Ship Engineering Center.

Improvements are usually staffed through the Life Cycle Support Activity (LCSA) at the Naval Underwater Systems Center prior to being submitted to the ICB. This staffing is a preliminary review to determine rough magnitudes of impact and scope. The Board reviews the recommended improvements and determines if the improvements should be approved. If they are to be approved then the priority is set with a preliminary schedule. The improvements are then processed through the organization with LCSA tasked to do the designing, coding, testing, documenting, and implementing into the Fleet.

PARTICIPATING DEVELOPER MANAGER (PDM)

The PDM is responsible to NAVSEA for the design, development, fabrication and testing of new combat control systems, sub-systems and software modules. These systems, sub-systems and software modules range from next generation equipment down to the modifications necessary to intergrade new sensor or weapon systems into the combat control system. The PDM's responsibility for a system is transferred to maintenance groups after operational acceptance.

NAVAL SHIP ENGINEERING CENTER

The SSN Weapon System is a combination of sensors, displays, weapons, navigation, command and control etc. that utilize the digital computer. NAVSEC has the responsibilities for navigation, common program, and the central computer

complex hardware.

FLEET

The Fleet, as shown on the Organization Chart, is the end user of the system and thus provides the prime input to the Life Cycle Support Activity on problem areas via Problem Technical Reports (PTRs) and also recommends improvements to the ICB for consideration.

LIFE CYCLE SUPPORT ACTIVITY (LCSA)

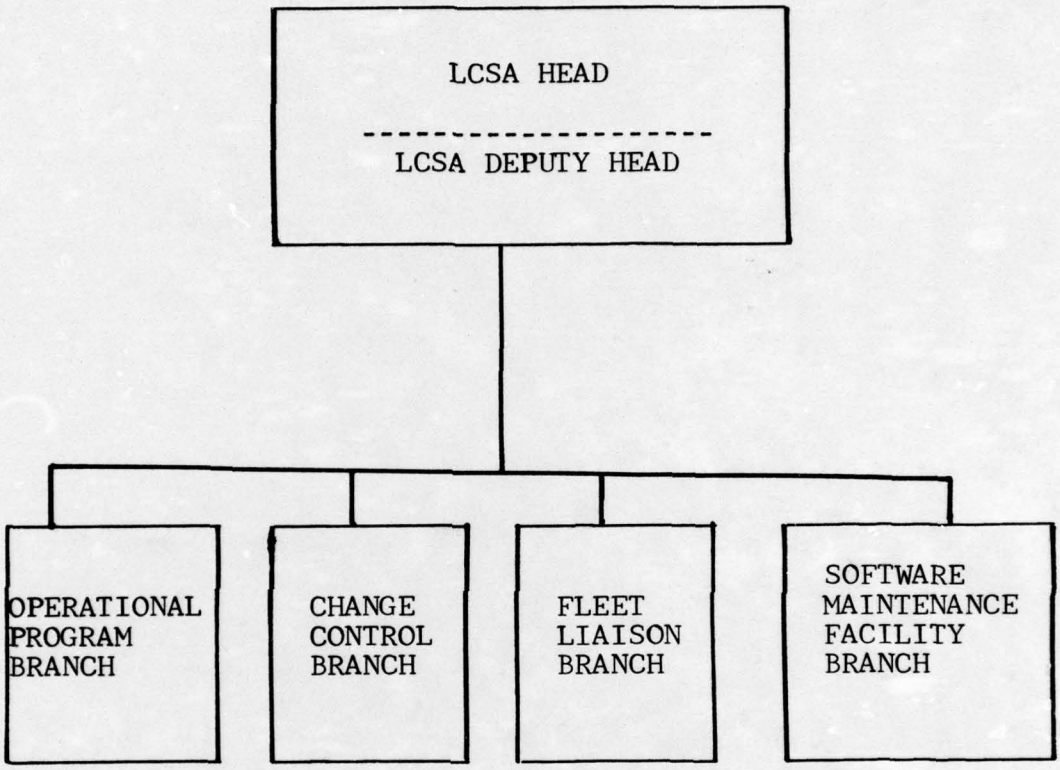
The LCSA was established to correct, update, modify, integrate, test and deliver operational software to the Fleet. The LCSA organizational structure to carry out these tasks is depicted in Figure 2.

OPERATION BRANCH

The Operational Branch of the LCSA is a collection of software experts who know the program down to the module level and are systems oriented. This branch is the focal point for operational program modifications, operational evaluation, software documentation and is the corporate configuration memory. The other branches will rely on this branch for detailed information as the program changes.

CHANGE CONTROL BRANCH

The Change Control Branch is the focal point of Configuration Management for the operational programs and currently provides support to the SSN ICB on items presented to the Board. Within this Branch there has been established an operational software program library which maintains the master copies



LIFE CYCLE SUPPORT ACTIVITY
ORGANIZATION CHART

Figure 2

of all documentation. These master copies represent the baseline for each software configuration item in the SSN Fleet. The Configuration item baseline, which is the product baseline, as currently established, is based on a Functional Configuration Audit (FCA) and a Physical Configuration Audit (PCA). The audits are verification that the delivered software meets the specifications including the Computer Program Performance Specifications (CPPS) (D5 D4). Configuration Control is in accordance with (D4) and the Change Control Board (CCB) which consists of voting members from all branches of the LCSA. The CCB treats each proposed change as an Engineering Change Proposal. Class I ECPs are submited to NAVSEA for review and approval prior to delivery to the Fleet. Deliveries to the Fleet, shore activities and other users are planned to be accomplished by the NAVSEA Ordnance Alteration (ORDALT) procedures (D18). Details of the LCSA delivery package are being prepared. It is expected the package will consist of a complete computer program on a disk for each specific ship, detailed description of operation and maintenance procedures as well as any peculiar information to that delivery. If the delivery is complex then the LCSA Fleet Liason Branch will install the package and check the system out.

Configuration status accounting for the operational software is a large task since the Fleet population is over one hundred SSNs which will have several different configurations.

The current approach is a Computerized Information Retrieval System (CIRS) under the Change Control Branch which tracks and maintains record of each SSN configuration. The following types of information is maintained in the CIRS files:

- Hardware Master Configuration
- Software Master Configuration
- Active/Complete Programs Files
- Problem Status per SSN

FLEET LIAISON BRANCH

The Fleet Liason Branch is the link between the LCSA and the Fleet as well as other activities utilizing operational software, such as training and the PDM. In its liaison function with the Fleet this Branch assists in identifying problems, reporting problems and performing other functions such as delivering and checking out modified software programs. The baseline information is under tight control and liaison with the PDM is maintained in accordance with (D11). This Branch not only provides information to the PDM but also has the responsibility to review new programs prior to being turned over to the LCSA from the PDM. This review is to assure that all applicable documentation is in accordance with (D5), to validate the product baseline against its documentation and to recommend to NAVSEA program acceptance/rejection and deficiencies. If the deficiencies are major then NAVSEA may elect to return the program to the PDM for correction. Future programs under the PDM's cognizance are being planned such that representatives from the LCSA will

participate in the different phases of the software development cycle. Their participating will occur during all phases of a program and will include the establishment of the Functional, Allocated, and Product Baselines as well as their participation during preliminary and critical design reviews. After the program has been turned over to the LCSA it is placed under Configuration Control.

SOFTWARE MAINTENANCE FACILITY (SMF)

This is the last branch within the LCSA and is the backbone of the organization. This branch designs, obtains, maintains, implements and operates the facilities to support the full operation of the LCSA. This includes complete Combat Control Systems, Simulation/Stimulation (SIM/STIM) hardware and software and all necessary hardware configurations to reflect those in the Fleet.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS AND RECOMMENDATIONS

In reviewing the limited policy and procedures governing Operational Software, Life Cycle Management (OSLCM), it appears that the SSN Combat Control OSLCM is not only conforming to the policy and procedures but could be used as the basis for generating new and more detailed procedures. There are several areas of concern that should be reviewed and changes considered. These areas are as follows:

- Utilization of an outside activity to provide Verification and Validation.
- Control of the product baseline by, as a minimum, the Computer Design Specifications vice the Computer Performance Specifications and possibly should be controlled by the Computer Program Description Document.

The Combat Control Systems are being developed by the PDM which is the Naval Underwater Systems Center, Newport, RI. The PDM was established at the Naval Underwater Systems Center several years ago and given total systems integration responsibility. The hardware is procured from several manufactures and integration, programming and testing is performed by the PDM. After the system has passed operational tests they are turned over to the Naval Undewater Systems Center LCSA for operational maintenance. The utilization of an independent Verification and Validation group would provide the Navy with an outside opinion as to readiness of a program as well as keep "invented here" attitudes from over shadowing potential pro-

blems.

The other area of consideration for change is the means by which the baseline is established and maintained. With the baseline identified by the Computer Performance Specifications there is too much latitude in how each module can be reprogrammed. If the modules are not closely controlled, a simple change could ripple completely through the program. This rippling effect could create problems with other modules in the operational programs as well as impact integration of modules, being developed by the PDM, into the operational programs. Problems due to the rippling effect will eventually translate into delivery delays, cost increases and reliability.

The conclusions and recommendations of this report will be provided to the Naval Sea Systems Command (660D) program office for consideration/incorporation into the LCSA management.

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